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CANTOX INC.
Consultants in Toxicology

PART II REPORT

VECTOR SCORING SYSTEM FOR THE PRIORITIZATION OF CHEMICAL CONTAMINANTS

PREPARED BY: CanTox Inc and SENES Consultants Ltd
and
Priority List Working Group,
Ontario Ministry of the Environment

January, 1987

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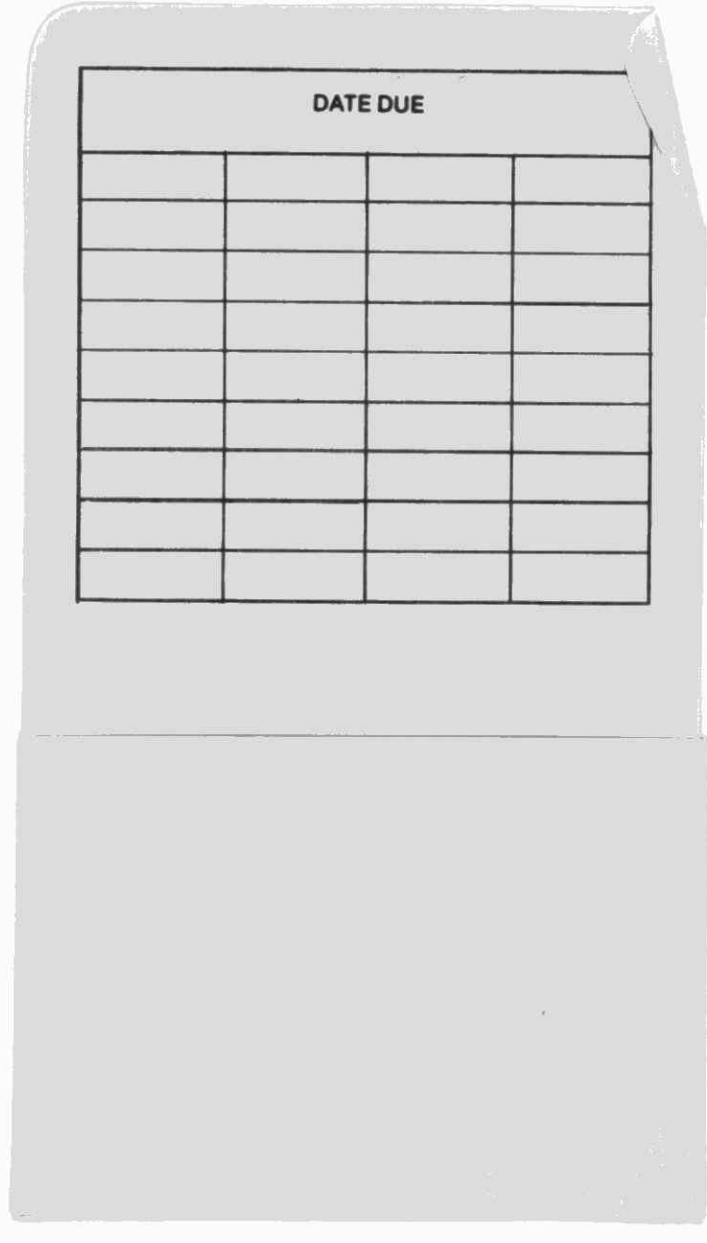
Head Office:
460 Wyecroft Road, Oakville, Ontario, Canada L6K 2G7 (416) 845-3872



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PART II REPORT

MOE VECTOR SCORING SYSTEM

1. INTRODUCTION

In November 1985, a team of scientists and engineers assembled by CanTox Inc and Senes Consultants Limited were engaged by the Ontario Ministry of the Environment (MOE) to provide scientific and technical expertise for the development, review and testing of a methodology for prioritization of the potential environmental and health hazards of chemicals. Part I of the project, prepared as a separate report, focused on the development and documentation of a vector scoring system for the screening and prioritization of chemicals to identify those requiring detailed environmental and health assessment. Part II of the project, summarized in this report, involved the testing of the scoring system on a series of thirty-two (32) chemicals identified by the MOE.

The major components of the scoring system described in the Part I report are summarized in Appendix 1. Briefly, the scoring system consisted of three phases. Phase 1 served to focus the scoring system onto chemicals of potential concern in Ontario. In Phases 2 and 3, a vector was used to describe the key properties or characteristics of chemicals important to their prioritization for assessment of their potential environmental and health hazards. Each of these properties or characteristics relevant to this assessment was represented as a vector element. Scores were assigned to the vector elements based on a strategy that increased in sophistication and complexity with progression from Phase 2 to Phase 3 of the scoring system. The magnitude of the score assigned to each vector element reflected the level of concern attributed to that property of the chemical. Score modifiers (! = worst-case estimate, ? =

questionable data and * = inadequate information) were applied to indicate the level of confidence in the assigned element scores. Rules were also developed for combining element scores in order to develop various priority lists to be used for the selection of chemicals for in-depth regulatory consideration.
To test the vector system in Part 2 of the project, 32 individual chemicals (see Table 1) were scored based on the vector-system criteria summarized in Appendix 1. These scores were then compared with an independent environmental and health evaluation of each chemical. This report summarizes the performance of the scoring system when applied to the 32 test chemicals, recommends changes to the vector scoring system to correct deficiencies identified through the testing program, and summarizes the scoring of the 32 test chemicals based on the modified scoring system.

2. METHODOLOGY

In Part II of the project, the performance of the scoring system was evaluated in five steps.

a) The 32 chemicals (Table 1) were scored using the vector scoring system.

b) The potential environmental and health effects of each of the 32 chemicals were assessed based on an independent environmental and health evaluation.

c) The congruence between the scoring and prioritization of the 32 chemicals based on the vector scoring system, and the results of the independent environmental health evaluation was assessed.

d) Problem areas in the scoring system were identified, and changes to the scoring system were proposed in an effort to rectify these problems.

e) The 32 chemicals were re-scored and re-prioritized based on the suggested modifications to the scoring system, and these scores were again compared with the potential hazards of the chemicals as indicated by the independent environmental health evaluations.

The procedures followed in each of these steps are outlined in the remainder of this section of the Part II report.

2.1. Scoring of Test Chemicals

2.1.1. Data Sources

The data for scoring the 32 chemicals were obtained from CESARS dossiers prepared on each chemical. An outline of the information contained in a typical CESARS dossier is presented in Appendix 2.

CESARS dossiers were prepared following two different procedures. For twenty-six (26) of the test chemicals, CESARS dossiers were obtained from the State of Michigan Department of Natural Resources through the MOE. When obtained, these dossiers were in varying condition and completeness for the different chemicals, ranging from simply "rough-notes", to out-of-date dossiers, to complete, current dossiers. The CESARS dossiers received were upgraded to a standard sufficient to enable documentation of the scoring of the chemicals involved. For the remaining six (6) of the 32 chemicals, complete CESARS dossiers were developed by the CanTox/SENES team. The source and initial condition of each CESARS dossier obtained are identified in Table 1.

Since the all 32 chemicals were scored for Phases 2 and 3 of the scoring system, independent dossiers for Phase 2 and Phase 3 were not developed. This approach biased the scoring of the chemicals, particularly in Phase 2, since a more in-depth search of the scientific literature was conducted than would

normally be undertaken for Phase 2 scoring. However, since many of the dossiers obtained from Michigan were based on a Phase 3-level of literature searching, it was not practical to re-do a Phase 2-level search on each chemical. Typical Phase 2 dossiers were prepared for none (9) chemicals by "down-scaling" the information available in the Phase 3-level dossier. This approach enabled an estimation of what would be contained in a Phase 2-level dossier.

Table 1. List of Test Chemicals

CHEMICAL	CAS #	CESARS	UPGRADE TYPE
acrylonitrile	107-13-1	Y	complete
aluminum	7429-90-5	N	CanTox/SENES
anthracene	120-12-7	Y	update
benzene	71-43-2	Y	complete
benzene, ethyl-	100-41-4	N	CanTox/SENES
benzene, hexachloro-	118-74-1	Y	complete
benzene, 1,2,4,5-tetrachloro-	95-94-3	Y	complete
benzene, 1,3,5-trichloro-	108-70-3	Y	complete
benzo(a)pyrene	50-32-8	Y	complete
cadmium	7440-47-9	Y	up-date
carbon tetrachloride	56-23-5	Y	up-date
chlorpyrifos	2921-88-2	N	CanTox/SENES
chromium	7440-47-3	N	CanTox/SENES
dehydroabietic acid	1740-19-8	N	CanTox/SENES
diazinon	333-41-5	Y	up-date
di(2-ethylhexyl)phthalate	117-81-7	Y	complete
ethylene, dichloro-	107-06-2	Y	complete
ethylene oxide	75-21-8	Y	complete
ethylene, trichloro-	79-01-6	Y	complete
fluoride, sodium	7681-49-4	N	CanTox/SENES
hexachlorocyclohexane, alpha-	319-94-6	N	CanTox/SENES
hexane	110-54-3	Y	complete
lead	7439-92-1	Y	complete
methane, dichloro-	75-09-2	Y	complete
mercury	7439-97-6	Y	up-date
mirex	2385-85-5	Y	up-date
nickel	7440-02-0	Y	complete
phenol	108-95-2	Y	complete
phenol, pentachloro-	87-96-5	Y	minor
selenium	7782-49-2	Y	complete
toluene	108-88-3	Y	update
toluene, 2,4,5-trichloro-	6639-30-1	N	CanTox/SENES

Due Feb 27

All information for up-dating or creating CESARS dossiers was obtained by searching the available scientific literature as outlined in the Part I report. Generally, a Chemical Abstracts Service computer search was conducted on each chemical. Specific search were conducted on the ENVIROFATE and other data bases for updating information in the environmental fate of chemicals.

2.1.2. Modifications to CESARS Dossier Format

Following discussions with the MOE staff, the following modifications were made to the general CESARS dossier format as originally developed by the Michigan Department of Natural Resources.

a) Discussion sections were added to summarize and interpret the information contained in specific sub-sections of the original dossiers. Generally, the discussion sections were restricted to information scribed elsewhere in the dossier (i.e., generally new information was not added in the discussions). If, however, information critical to the interpretation of the information contained in a particular sub-section of the CESARS dossier was available, this information was referenced separately in the discussions section. In addition, several of the CESARS dossiers consisted of "rough-notes" when received and were difficult to follow and decipher. In such circumstances additional references were added in the discussion sections when such information was regarded as critical to the interpretation of the available data on a particular sub-section of the dossier.

b) Field 142 (Mechanisms of Action) was added to the CESARS dossiers where appropriate. The information contained in this field was generally presented in a discussion format since the integration and interpretation of a wide range of data sources was usually required. In many cases information was included from other chemicals or involving the interactions of several chemicals, or from several other fields in the

CESARS dossier. The inclusion of such information did not lend itself to presentation in the form of individual sections on each research paper. Information on the potential mechanisms of action of chemicals was important in the interpretation of the toxicity data in other fields.

c) Scoring fields were added to each CESARS dossier. Fields 201 through 209 were used to record the scores for Phase 2 elements one through nine. Fields 301 through 315 were used to score Phase 3 elements one through 15. The field-element assignments are summarized in Appendix 2. Each scoring field lists the score assigned for the particular chemical, the data used in scoring, the sources of the data and any comments by the scorer (e.g., why score modifiers may have been used, why certain data were excluded, any questions on the data used, etc.).

2.2. Independent Environmental Health Hazard Evaluations

The general format of the information used in the independent environmental health evaluations of the 32 test chemicals is summarized in Appendix 3. Essentially the same scientific literature base (i.e., separate searches were not conducted) was used in the independent environmental health evaluation as in the preparation or updating of the CESARS dossier. Through the environmental health evaluation format, and the assessment of the data by a senior toxicologist, the available data were interpreted and that judged critical to determining the potential effects the chemical may have on the environment and human health was identified. Based on this assessment, the potential environmental health hazard of a chemical in Ontario was judged as low, intermediate or high. This grade assignment was then compared with the Phase 3 prioritization lists developed using the vector scoring system.

3. RESULTS

3.1. Vector-System Scores for Test Chemicals

3.1.1. General Information

The vector scoring system criteria used were as described in the Part I report and summarized in Appendix 1. The detailed supporting data used in the scoring are available in the individual CESARS dossiers which were provided to the MOE under separate cover. A summary of the element score fields from the CESARS dossiers for Phases 2 and 3 for each chemical are presented in Appendix 4.

Phase 3 CESARS dossiers were prepared for all 32 chemicals. Phase 2 CESARS dossiers were prepared for nine (9) chemicals by down-grading the Phase 3 CESARS dossiers (i.e., eliminating data sources not identified in the information sources for Phase 2, as described in the Part I document).

3.1.2. Phase 2 Element Scores of Test Chemicals

The element scores obtained by applying the Phase 2 vector scoring system criteria to the 32 test chemicals are summarized in Appendix 4, Table A4-1. The frequency distribution of scores for each element for the 32 test chemicals in Phase 2 are presented in Table 2.

The distribution of scores were comparable among the individual elements, except for elements P2E6 (Bioaccumulation) and P2E9 (Aesthetic Properties). The percentage of the 32 chemicals that received scores of 3 ranged from 38% to 78% (mean 60.4%) over all elements except P2E6 and P2E9. For element P2E6, 12.5% of the chemicals received a score of 3, 47% a score of 2 and 31% a score of 1. In the case of P2E9, the distribution was 3%, 38% and 12% for scores of 3, 2 or 1, respectively. Since most of the 32 chemicals provided for assess-

ment were known toxin of concern in the environment, most should receive high scores, especially in Phase 2.

The percentage of the 32 test chemicals with asterisks (inadequate information) in a given element, excluding P2E9, ranged from 0 to 19%. The available information was inadequate for elements P2E1 (Sources) and P2E5 (Environmental persistence) for 10% and 16%, respectively of the test chemicals. The frequency of inadequate information ranged from 0 to 6% of the 32 test chemicals for the remaining elements. The highest frequency (44%) of inadequate information among the 32 chemicals was in element P2E9 (aesthetic properties).

3.1.3. Phase 2 Priority Listing of Test Chemicals

The chemicals were assigned to priority lists based on the application of the Phase 2 combining rules (see Appendix 1) to the vector-system scores for the 32 test chemicals as summarized in Appendix 4, Table A4-1. The combining-rule sums and the Phase 2 vector element for each of the 32 chemicals are presented in Table 3.

Thirty-one of the 32 test chemicals entered priority list P2L1, none entered lists P2L2 or P2L3, 17 entered list P2L4 (undesirable aesthetic properties), and one test chemical entered list P2L5 (inadequate information) (see Table 3).

Twenty-three of the test chemicals on list P2L1 received a maximum combining-rule sum of nine (9), five (5) received combining-rule scores of 8, one (1) received a score of seven (7) and two received scores of six (6). Under actual operating conditions, the 23 chemicals with the highest combining-rule sums would be receive first priority for entry into Phase 3 for more detailed evaluation. These would be followed by chemicals with combining-rule sums of 8, then 7 and so forth. List P2L4 identifies chemicals with undesirable aes-

thetic properties. List P2L5 identifies those that would not pass to Phase 3 because of inadequate information. The list P2L5 chemicals would be re-assessed in Phase 2 after the missing data had been gathered.

Since most of the 32 chemicals provided for assessment were known toxins of environmental concern, the observed distribution between priority lists should not be regarded at typical of how the scoring system would perform on a group of unknown chemicals.

Table 2. Frequency Distribution of Phase 2 Scores (Scored with Unmodified Criteria)

ELEMENT NUMBER	*	?	!	ELEMENT SCORE 0	1	2	3
P2E1	6	4	4	0	0	2	24
P2E2	0	3	3	0	2	9	21
P2E3	1	1	0	0	2	6	23
P2E4	2	0	0	3	9	6	12
P2E5	5	2	2	8	4	3	12
P2E6	1	2	4	2	10	15	4
P2E7	1	3	7	1	3	9	18
P2E8	1	1	2	0	3	3	25
P2E9	14	1	0	1	4	12	1

Table 3. Phase 2 Priority Selection Lists

CHEMICAL	PHASE 2 VECTOR									RULE SUM
PRIORITY LIST P2L1										
acrylonitrile	{3	2	*	3	0	1	3	3	1}	9
aluminum	{3	3	3	0	3	2	3!?	2!	*}	9
benzene	{3	3	3	3	0	1	2	3	2}	9
benzene hexachloro-	{3?	3?	3	1	3	3	3	3	*}	9
benzo(a)pyrene	{*	3	3	3	1	3	2!	3	*}	9
cadmium	{3!	3	3	1	3	1!	3!	3	*}	9
carbon tetrachloride	{3	3	3	3	2	1	2	3	2}	9
chromium	{3	3	3	3	3	2	2	3	2}	9
diazinon	{2	3	3	2	2	1	3	1	*}	9
diethylhexylphthalate	{3?	3	3	3	1	2	2	3	*}	9
ethane dichloro-	{3	2	2	3	0	1	1	3	1}	9
ethylene trichloro-	{3!?	2	3	3	0	2!	2!	3!	1}	9
fluoride	{3!	3	3	3	3!?	1	3	3	2}	9
hexachlorocyclohexane	{*	3	3	0	3!?	2!	3	3	2}	9
hexane	{3	3	3	3	1	2?	0	3	*}	9
lead	{3	3	3	1	3	2	3	3	*}	9
methane dichloro-	{3	3	3	3	1	0	2	3	2}	9
mercury	{3	2	3	1	3	3!	3	3	0?}	9
mirex	{3!?	3!	2	1	3	3	3?	3	*}	9
nickel	{3	3	3	2	3	2	3!	3	*}	9
phenol pentachloro-	{3!	3	3	1	3	2	3	3	2}	9
selenium	{3	2	3	1	3	2	3	3	2}	9
toluene	{3	3	3	2	0	1	3	3	2}	9
benzene, tetrachloro-	{*	2	1	1	*	2	3	3	2}	8
benzene, trichloro-	{*	2	2	2	*	2	3!?	3?	2}	8
chlorpyrifos	{2	3!?	3	1	2	2	3	2	*}	8
ethylene oxide	{3?	2	2	2	*	*	2	3	1}	8
phenol	{3	3	3	3	0	0	2	2	2}	8
anthracene	{3	3	3	0	0	2	1!	1	*}	7
benzene, ethyl-	{3	1	1	2	0	1	1	1	3}	6
toluene, trichloro-	{*	1	2	*	*	2	3	3	*}	6

Table 3 Phase 2 Priority Selection Lists

CHEMICAL	PHASE 2 VECTOR	RULE SUM
PRIORITY LIST P2L2		
(None)		
PRIORITY LIST P2L3		
(None)		
PRIORITY LIST P2L4		
(Ranked according to P2E9 score)		
benzene ethyl-	{3 1 1 2 0 1 1 1 3}	
benzene	{3 3 3 3 0 1 2 3 2}	
benzene tetrachloro-	{* 2 1 1 * 2 3 3 2}	
benzene trichloro-	{* 2 2 2 * 2 3!? 3? 2}	
carbon tetrachloride	{3 3 3 3 2 1 2 3 2}	
chromium	{3 3 3 3 3 2 2 3 2}	
fluoride	{3! 3 3 3 3!? 1 3 3 2}	
hexachlorocyclohexane	{* 3 3 0 3!? 2! 3 3 2}	
methane dichloro-	{3 3 3 3 1 0 2 3 2}	
phenol	{3 3 3 3 0 0 2 2 2}	
phenol pentachloro-	{3! 3 3 1 3 2 3 3 2}	
selenium	{3 2 3 1 3 2 3 3 2}	
toluene	{3 3 3 2 0 1 3 3 2}	
acrylonitrile	{3 2 * 3 0 1 3 3 1}	
ethane dichloro-	{3 2 2 3 0 1 1 3 1}	
ethylene oxide	{3? 2 2 2 * * 2 3 1}	
ethylene trichloro-	{3!? 2 3 3 0 2! 2! 3! 1}	
mercury	{3 2 3 1 3 3! 3 3 0?}	
PRIORITY LIST P2L5		
dehydroabietic acid	{* 2? 2? * * 1? * * *}	3*

3.1.4. Phase 3 Element Scores of Test Chemicals

The scores obtained by applying the Phase 3 vector scoring system criteria to the 32 test chemicals are summarized in Appendix 4 Table A4-2. The frequency distribution of scores for each element for the 32 test chemicals in Phase 3 are presented in Table 4.

The distribution of scores were reasonably comparable among 13 of 14 of the Phase 3 elements. The score distribution for element P3E15 was not evaluated since this element is merely a repeat of element P2E9 to ensure that the scores for undesirable aesthetic properties are retained in the Phase 2 vector.

The distribution of vector-element scores for P3E7 showed a much higher frequency of 10-scores than other elements (see Table 4). This element was included in the scoring system to account for the frequency of distribution of chemicals in the environment (expressed as release-days). However, when scoring the 32 test chemicals information on release-days was seldom, if ever, available. Therefore element P3E7 scores were developed intuitively based on information available on the type and frequency of use of the chemical. This intuitive assessment resulted in a high frequency of high scores (8 or 10). From the information on the problems with scoring this element and the markedly abnormal distribution of scores obtained, it was evident that the element was not reliable.

Table 4. Frequency Distribution of Phase 3[a] Scores (Scored with Unmodified Criteria)

ELEMENT NUMBER	*	?	!	ELEMENT SCORE 0	2	4	6	8	10
P3E1	16	3	3	0	8	3	4	1	0
P3E2	3	1	8	0	14	9	4	2	0
P3E3	23	1	2	0	2	2	3	0	2
P3E4	10	4	3	0	6	8	1	3	4
P3E5	22	1	4	0	2	0	2	2	4
P3E6	16	2	3	1	3	2	4	5	2
P3E7	1	1	1	0	3	3	1	4	20
P3E8	1	3	3	1	3	9	9	6	3
P3E9	9	6	2	0	7	4	7	2	3
P3E10	11	2	0	4	7	4	5	0	1
P3E11	2	3	2	0	5	8	6	6	5
P3E12	5	1	1	10	7	2	8	0	0
P3E13	3	6	2	11	1	1	7	3	6
P3E14	7	4	2	6	2	3	4	3	7

a Element P3E15 excluded since it was only a duplicate of element P2E9 and had a maximum potential score of 3, rather than 10 as for other Phase 3 elements.

3.1.5. Phase 3 Priority Listing of Test Chemicals

The chemicals were assigned to priority lists based on the application of the Phase 3 combining rules (see Appendix 1) to the vector-system scores for the test chemicals as summarized in Appendix 4, Table A4-1. The combining-rule sums and the Phase 3 vector element for each of the 32 chemicals are presented in Table 5.

Based on the combining-rule sums, twenty-four (75%) of the chemicals entered priority list P3L1, five (16%) chemicals entered priority list P3L2, one (3%) chemical entered priority P3L3, four (12%) entered list P3L4 (aesthetic properties), and two (6%) entered list P3E5 (inadequate information). Two of the test chemicals (ethylene oxide and acrylonitrile) entered priority list P3L1 because of scores ≥ 8 in elements P3E8 through P3E14, even though the information available for the application of the combining rules was not adequate.The high percentage of test chemicals that entered list P3L1 may reflect the tendency for a distribution of high scores for element P3E7.

The distribution of combining-rule sums, which would be used for assigning within-list priorities, for list P3L1 appeared reasonable and are summarized in Table 6. Since the chemicals with the highest combining-rule sums in list P3L1 should receive the highest priority for detailed regulatory consideration, the "even" distribution of list P3L1 combining-rule sums would provide for an orderly assessment of the chemicals without the need to select between large numbers of chemicals with the same combining-rule sums.

Table 5 Phase 3 Priority Lists (Unmodifed Rules)

CHEMICAL	PHASE 3 ELEMENT VECTOR															RULE SUM
PRIORITY LIST P3L1																
benzo(a)pyrene	(*	*	10!	*	*	*	10	4!?	10	*	8	2	10	10	*)	40
lead	(2	4	10?	10?	10	10	10	6	6	4	8	6	0	2?	*)	40
mercury	(2	2	6	6	6!	8!	10	8	4?	10	10	6	6	0?	0?)	38
nickel	(4!	4!	2	10	10!	*	10	4	4	4	10	6	6!	8	*)	38
benzene	(6	4	*	*	*	*	10	4	4?	2	4	0	10	10	2)	36
benzene, hexachloro-	(*	6	*	4	*	2	10	6	10	*	10	0?	0?	10?	*)	36
chromium	(2	4	4	8	8	6	10	6	6	2	6	6	10?	8	2)	36
aluminum	(2	8	*	10	10?	*	10	8?	6?	6?	6?	2	0?	*	*)	34
diazinon	(*	6	*	4	2	2	8	10	6	4	10!	0	0	0	*)	34
fluoride, sodium	(4	8	6	*	8	8	10	6	*	*	8	4	8	0?	2)	34
methane, dichloro-	(4?	2	*	*	*	*	10	4	*	0	6	0	10	10	2)	34
mirex	(*	2!	*	2	*	8!	10	8	6	6	8	6	0	8	*)	34
selenium	(*	4!	6	10	10	*	10	6	8!	6	8	6	6	6	2)	34
benzene, tetrachloro-	(*	2	*	4	*	8	8	8	2	2	6	0	8	*	2)	32
cadmium	(2	2	2	2	6!	6	10	8	8	6	8	6!	8!	6!	*)	32
chlorpyrifos	(2!?	2!	*	2!?	*	*	8	10	10	*	10	*	*	0	*)	30
diethylhexylphthalate	(2	4	*	4	*	8	10	2	6	0	4	2	6?	6	*)	30
phenol, pentachloro-	(*	4	*	4?	*	6	10	6	6	4	6	6	6	4	2)	28
ethane, dichloro-	(2?	2	*	*	*	0?	4	2	*	0	2	0	10	10	1)	26
phenol	(*	6!	*	8!?	*	*	10	4	2	2	4?	0	2	4!	2)	26
toluene	(8	4	*	2	*	*	10	6	2	*	2	2	0	0	2)	26
ethylene, trichloro-	(6!	4!	4!	4!	*	*	8	4!	2?	*	4	2	6	2	1)	24
acrylonitrile	(*	*	*	*	*	*	4	10	*	6	6	4	4	10	1)	*
ethylene oxide	(*	*	*	*	*	*	4	4	*	*	2	2	10	10	1)	*
PRIORITY LIST P3L2																
carbon tetrachloride	(*	2	*	*	*	*	10	4	2?	2?	4	2	0	6	2)	22
hexane, hexachlorocyclo	(*	2	*	4	2!	4	6!	6	4	2	4	*	6	4	2)	22
anthracene	(*	2!?	*	2	*	4!?	10	4!	2!?	0	2!?	*	0	0	*)	20
hexane	(6	2	*	*	*	*	10	0	*	*	4	0	0?	*	*)	20
benzene, trichloro-	(*	2	*	2	*	2	2?	6?	*	*	4	0	0?	*	2)	14

Table 5 Phase 3 Priority Lists (Unmodifed Rules)

CHEMICAL	PHASE 3 ELEMENT VECTOR	RULE SCORE
PRIORITY LIST P3L3		
benzene, ethyl-	⟨6 2 * * * * 2 2 * 2 2 0 0 * 3⟩	12
PRIORITY LIST P3L4 (Sorted according to P3E15 scores)		
benzene, ethyl-	⟨6 2 * * * * 2 2 * 2 2 0 0 * 3⟩	
carbon tetrachloride	⟨* 2 * * * * 10 4 2? 2? 4 2 0 6 2⟩	
hexane, hexachlorocyclo	⟨* 2 * 4 2! 4 6! 6 4 2 4 * 6 4 2⟩	
benzene, trichloro-	⟨* 2 * 2 * 2 2? 6? * * 4 0 0? * 2⟩	
PRIORITY LIST P3L5		
dehydroabietic acid	⟨* 6! * 8 * * * * * * * * * * *⟩	14*
toluene, trichloro-	⟨* 2 * 4 * 6 2 8 2 * * * * * * *⟩	10*

Table 6. Combining-rule Score Distribution for List P3L1

Combining-rule Sum	Number of Chemicals
40	2
38	2
36	3
34	6
32	2
30	2
28	1
26	3
24	2
16	1

3.2. Independent Environmental Health Hazard Evaluation of Test Chemicals

3.2.1. General Information

Independent environmental health hazard evaluations were conducted for the 32 test chemicals following the format outlined in Appendix 3. These evaluations are available from the MOE under separate cover.

3.2.2. Independent Classification of Test Chemicals

The classifications of the 32 test chemicals based on the independent environmental health hazard evaluations are summarized in Table 7, together with the list assignment according to the Vector Scoring System Phase 3 combining rules. Based on this evaluation, nineteen (19) of the test chemicals were rated as potential high environmental health hazards, six (6) were intermediated, four (4) were low and the information available on two (2) chemicals was inadequate for assessment.

3.3. Comparison of Vector-System Scores and Independent Classification

There was good general agreement between the independent environmental health hazard ratings and the scores developed with the vector system combining rules. Those chemicals rated as high environmental health hazards were generally found on list P3L1. The test chemicals rated as intermediate were also generally found on list P3L1. Those chemicals rated as low environmental hazards were found on lists P3L2 or P3L3.

The two chemicals rated as "inadequate information" in the independent evaluation were on list P3L5, also indicating inadequate data. The two chemicals that did not agree between the independent evaluation and the scoring system were carbon tetrachloride and hexane. Carbon tetrachloride was rated as

having a high potential environmental health hazard, whereas it was on list P3L2 as assessed by the scoring system. Hexane was rated as an intermediate environmental health hazard but was listed on P3L2.

Table 7. Independent Rating of Test Chemicals

CHEMICAL	CanTox HAZARD RATING	PHASE 3 COMBINING-RULE SUMS	
acrylonitrile	high	P3L1	16*
benzene	high	P3L1	36
benzene, hexachloro-	high	P3L1	36
benzo(a)pyrene	high	P3L1	40
cadmium	high	P3L1	32
carbon tetrachloride	high	P3L2	22
chlorpyrifos	high	P3L1	30
chromium	high	P3L1	36
diazinon	high	P3L1	34
diethylhexylphthalate	high	P3L1	30
ethane, dichloro-	high	P3L1	26
ethylene oxide	high	P3L1	24*
hexachlorocyclohexane	high	P3L1	22
lead	high	P3L1	40
methane, dichloro-	high	P3L1	34
mercury	high	P3L1	38
mirex	high	P3L1	34
phenol	high	P3L1	26
phenol, pentachloro-	high	P3L1	28
aluminum	intermediate	P3L1	34
benzene, tetrachloro-	intermediate	P3L1	32
ethylene, trichloro-	intermediate	P3L1	24
fluoride, sodium	intermediate	P3L1	34
hexane	intermediate	P3L2	20
nickel	intermediate	P3L1	38
selenium	intermediate	P3L1	34

Table 7 Independent Rating of Test Chemicals

CHEMICAL	CanTox HAZARD RATING	PHASE 3 COMBINING-RULE SUMS	
anthracene	low	P3L2	20
benzene, ethyl	low	P3L3	12
benzene, trichloro-	low	P3L2	14
toluene	low	P3L2	26
dehydroabietic acid	inadequate information	P3L5	14*
toluene, trichloro-	inadequate information	P3L5	10*

4. DISCUSSION

4.1. Phase 2 Vector

4.1.1. General Observations

The vector elements for Phase 2 appeared to adequately describe those chemical characteristics important in an initial prioritization of chemicals. The information required for scoring the nine (9) Phase 2 elements was readily available from summary information sources. The scores could be assigned to the Phase 2 elements quickly, without a requirement for a great deal of data interpretation. The use of "most sensitive indicators" for establishing scores tended to provide a worst-case assessment of each chemical and bias the scoring "on the side of safety". This, however, was not considered to the detriment of the Phase 2 vector. It was generally considered that its main function was to prioritize chemicals for entry into Phase 3 and to ensure, as much as possible, that chemicals with potential for adverse environmental and health effects would not be eliminated from further consideration. The Phase 2 vector appeared to meet these requirements.

The fact that all of the test chemicals with adequate information received high scores in Phase 2 was not unexpected. Most of the test chemicals were known environmental toxins of some concern, therefore the most of them should have passed to Phase 3.

4.1.2. Phase 2 Combining Rules

The Phase 2 combining rules grouped all of the test chemicals in list P2L1. As already indicated, this may be reasonable based on the high level of environmental and health concerns known to be associated with the 32 test chemicals. However, it would be desirable to have a greater spread in the combining-rule sums to facilitate prioritization of the entry of chemicals

into Phase 3.

4.2. Phase 3 Vector

4.2.1. General Observations

The 15 elements of the Phase 3 vector focused on three types of information on chemicals. Element P3E15 identified chemicals with undesirable aesthetic characteristics and simply represented a duplication of element P2E9 from Phase 2. Elements P3E1 through P3E7 focused on parameters affecting level of exposure. P3E1 through P3E6 provided scores for concentrations of chemicals in the environment (e.g., air, water, soil, sediment, plants and animals). As indicated in Table 4, there was a high frequency of asterisk (*) scores for the elements for soil, animals, air, plants, and sediments, indicating inadequate information for 72%, 50%, 50%, 38% and 31% of the chemicals, respectively. However, since the prioritization system used was not dependent on all, or any one of these environmental levels elements, there was usually enough information available on the test chemicals to utilize the combining rules.

Element P3E7 (Frequency of Releases) was designed to provide a surrogate for the frequency of exposure to a chemical. This element was unsatisfactory because the information available resulted in high scores (8 or 10) for 29 of the 32 test chemicals.

The range of scores for the various Phase 3 elements appeared to provide a reasonable range of representation of level of concern. P3E15 was based on a maximum total score of 3 and was included in Phase 3 to insured that chemicals with undesirable aesthetic properties were identified. All other elements in Phase 3 had potential scores between zero (0) and ten (10), and increased in increments of 2. No problems were identified in the application of the scores, or in their utilization for chemical prioritization.

4.2.2. Phase 3 Combining Rules

The Phase 3 combining rules appeared to perform adequately on the 32 test chemicals. As with the Phase 2 rules, however, a wider spread in Phase 3 combining-rule sums would be desirable to facilitate the prioritization of chemicals for detailed regulatory assessment after Phase 3. The high frequency of high scores for element P3E7 would have resulted in an increase in the number of chemicals in priority list P3L1.

4.3. Congruency of Phase 3 Scoring and Independent Classification

Even considering the problems identified with the Phase 2 combining rules, Phase 3 elements and Phase 3 combining rules as discussed above, there was good agreement between the Phase 3 priority listing and the independent ranking of the potential environmental and health hazards of the test chemicals. The agreement was particularly good for those chemicals identified as potentially high environmental and health concerns. The agreement with chemicals ranked as low potential concern was less satisfactory.

4.4. Recommended Modifications to Vector-System Criteria

4.4.1. Vector Elements

No changes are recommended to the Phase 2 Vector Element Criteria.

Based on the difficulties encountered in scoring element P3E7, it is recommended that this element be deleted from the scoring system and replaced with an element describing the environmental persistence of chemicals. The original purpose of element P3E7 was to provide an indicator of frequency of exposure in the scoring system. Frequency of release was chosen as a surrogate for exposure frequency. Environmental persistence would also serve as

a surrogate for exposure frequency, since the more persistent a chemical, the longer it will remain in the environment and the greater the potential frequency of exposure. The recommended changes in criteria for element P3E7 have been derived by expanding the criteria for P2E5 as outlined in Table 8.

The use of persistence criteria causes difficulties in scoring naturally occurring elements, since they have infinite persistence in the environment. To correct this difficulty it is recommended that the assessment of persistence of natural elements be based on their half-lives in air, water, plants and animals, but not soils or sediments. It is recognized that high levels of natural elements in soils and sediments can present environmental and health hazards, however, these concerns are addressed in Phase 3 elements P3E1 through P3E6 on environmental levels. If the persistence of natural elements in soils and sediments is included in the scoring criteria for element P3E7, all natural elements would receive scores of ten (10) and their priority assessment by the scoring system would be biased.

Table 8. Recommended Modified Criteria for Element P3E7 (Environmental Persistence)

ELEMENT SCORE	SCORING CRITERIA ENVIRONMENTAL HALF-LIFE (DAYS)[a]	VERBAL
10	>200	Very persistent in > one compartment.
8	>100 - 200	Very persistent in one compartment only.
6	>50 - 100	Moderately persistent in > one compartment.
4	>25 - 50	Moderately persistent in one compartment only.
2	>10 - 25	Slightly persistent.
0	≤10	Not persistent.

[a] For naturally occurring elements (e.g., metals), indicators of persistence in soils and sediments will not be used in scoring. Scores will be based on half-lives or verbal descriptions derived from air, water, plants or animals.

4.4.2. Combining Rules

No serious problems were identified in the combining rules as outlined in Appendix 1, however, minor changes in the rules are recommended in order to facilitate in the prioritization of chemicals by providing a wider spread in combining-rule sums. In the Phase 2 combining rules, it is recommended that the limit for the entry of a chemical onto list P2L1 be changed from ≥ 6 to >6 and for list P2L2 from ≥ 4 to >4. In the Phase 3 combining rules, it is recommended that the limits for entry onto priority lists P3L1 and P3L2 be changed from ≥ 24 and ≥ 14 to >24 and >14, respectively. The modified Phase 2 and Phase 3 combining rules are outlined in Appendix 5, Figures A5-1 and A5-2.

4.5. Impact of Modifications on the Scoring of Test Chemicals

4.5.1. Phase 2 Scores

Since no changes were made to the Phase 2 elements or their criteria, no changes would occur in the Phase 2 scores. To facilitate comparisons, the Phase 2 scores for the test chemicals are included in Appendix 5, Table A5-1.

4.5.2. Phase 3 Scores

The effect of changing element P3E7 from a measure of frequency of dispersion to one based on environmental persistence (see Table 8) changed the scoring of the 32 test chemicals in Phase 3. These changes are summarized in Appendix 5, Table A5-2. The impact of the changes in the P3E7 element is discussed in the assessment of the Priority Lists.

4.5.3. Modified Priority Lists

4.5.3.1. Phase 2 Lists

The recommended modifications to the Phase 2 combining rules changed slightly the listing of the chemicals by moving two chemicals onto list P2L2. This change would have little affect on the entry of chemicals into Phase 3. The results of the modified Phase 2 combining rules are summarized in Table 9.

Table 9. Phase 2 Priority Selection Lists

CHEMICAL	PHASE 2 VECTOR	RULE SUM
PRIORITY LIST P2L1		
acrylonitrile	{3 2 * 3 0 1 3 3 1}	9
aluminum	{3 3 3 0 3 2 3!? 2! *}	9
benzene	{3 3 3 3 0 1 2 3 2}	9
benzene hexachloro-	{3? 3? 3 1 3 3 3 3 *}	9
benzo(a)pyrene	{* 3 3 3 1 3 2! 3 *}	9
cadmium	{3! 3 3 1 3 1! 3! 3 *}	9
carbon tetrachloride	{3 3 3 3 2 1 2 3 2}	9
chromium	{3 3 3 3 3 2 2 3 2}	9
diazinon	{2 3 3 2 2 1 3 1 *}	9
diethylhexylphthalate	{3? 3 3 3 1 2 2 3 *}	9
ethane dichloro-	{3 2 2 3 0 1 1 3 1}	9
ethylene trichloro-	{3!? 2 3 3 0 2! 2! 3! 1}	9
fluoride	{3! 3 3 3 3!? 1 3 3 2}	9
hexachlorocyclohexane	{* 3 3 0 3!? 2! 3 3 2}	9
hexane	{3 3 3 3 1 2? 0 3 *}	9
lead	{3 3 3 1 3 2 3 3 *}	9
methane dichloro-	{3 3 3 3 1 0 2 3 2}	9
mercury	{3 2 3 1 3 3! 3 3 0?}	9
mirex	{3!? 3! 2 1 3 3 3? 3 *}	9
nickel	{3 3 3 2 3 2 3! 3 *}	9
phenol pentachloro-	{3! 3 3 1 3 2 3 3 2}	9
selenium	{3 2 3 1 3 2 3 3 2}	9
toluene	{3 3 3 2 0 1 3 3 2}	9
benzene tetrachloro-	{* 2 1 1 * 2 3 3 2}	8
benzene trichloro-	{* 2 2 2 * 2 3!? 3? 2}	8
chlorpyrifos	{2 3!? 3 1 2 2 3 2 *}	8
ethylene oxide	{3? 2 2 2 * * 2 3 1}	8
phenol	{3 3 3 3 0 0 2 2 2}	8
anthracene	{3 3 3 0 0 2 1! 1 *}	7

Table 9 Phase 2 Priority Selection Lists

CHEMICAL	PHASE 2 VECTOR	RULE SUM
PRIORITY LIST P2L2		
benzene ethyl-	{3 1 1 2 0 1 1 1 3}	6
toluene tetrachloro-	{* 1 2 * * 2 3 3 *}	6
PRIORITY LIST P2L3	(no chemicals on this list)	
PRIORITY LIST P2L4	(Ranked according to P2E9 score)	
benzene ethyl-	{3 1 1 2 0 1 1 1 3}	
benzene	{3 3 3 3 0 1 2 3 2}	
benzene tetrachloro-	{* 2 1 1 * 2 3 3 2}	
benzene trichloro-	{* 2 2 2 * 2 3!? 3? 2}	
carbon tetrachloride	{3 3 3 3 2 1 2 3 2}	
chromium	{3 3 3 3 3 2 2 3 2}	
fluoride	{3! 3 3 3 3!? 1 3 3 2}	
hexachlorocyclohexane	{* 3 3 0 3!? 2! 3 3 2}	
methane dichloro-	{3 3 3 3 1 0 2 3 2}	
phenol	{3 3 3 3 0 0 2 2 2}	
phenol pentachloro-	{3! 3 3 1 3 2 3 3 2}	
selenium	{3 2 3 1 3 2 3 3 2}	
toluene	{3 3 3 2 0 1 3 3 2}	
acrylonitrile	{3 2 * 3 0 1 3 3 1}	
ethane dichloro-	{3 2 2 3 0 1 1 3 1}	
ethylene oxide	{3? 2 2 2 * * 2 3 1}	
ethylene trichloro-	{3!? 2 3 3 0 2! 2! 3! 1}	
mercury	{3 2 3 1 3 3! 3 3 0?}	
PRIORITY LIST P2L5		
dehydroabietic acid	{* 2? 2? * * 1? * * *}	3*

4.5.3.2. Phase 3 Lists

The modified combining-rule sums and the Phase 3 vector element for each of the 32 chemicals are presented in Table 10. The vector element scores are based on the application of the recommended modifications to element P3E7.

Based on the combining-rule sums, nineteen (59%) of the chemicals entered priority list P3L1, seven (22%) chemicals entered priority list P3L2, four (12%) chemical entered priority P3L3, eight (25%) entered list P3L4 (aesthetic properties), and two (6%) entered list P3E5 (inadequate information). Two of the test chemicals (ethylene oxide and acrylonitrile) remained on priority list P3L1 because of scores ≥ 8 in elements P3E8 through P3E14, even though the information available for the application of the combining rules was not adequate.

The distribution of combining-rule sums, which would be used for assigning within-list priorities, for list P3L1 appeared reasonable and are summarized in Table 11.

Table 10 Phase 3 Priority Lists Based on Modified Criteria and Combining Rules

CHEMICAL	PHASE 3 ELEMENT VECTOR	RULE SUM
Priority List P3L1 (Modified P3E7 criteria)		
nickel	⟨4! 4! 2 10 10! * 10 4 4 4 10 6 6! 8 *⟩	38
benzene, hexachloro-	⟨* 6 * 4 * 2 10 6 10 * 10 0? 0? 10? *⟩	36
mercury	⟨2 2 6 6 6! 8! 8 8 4? 10 10 6 6 0? 0?⟩	36
selenium	⟨* 4! 6 10 10 * 4 6 8! 6 8 6 6 6 2⟩	36
aluminum	⟨2 8 * 10 10? * 6 8? 6? 6? 6? 2 0? * *⟩	34
chromium	⟨2 4 4 8 8 6 6 6 6 2 6 6 10? 8 2⟩	34
fluoride, sodium	⟨4 8 6 * 8 8 10 6 * * 8 4 8 0? 2⟩	34
lead	⟨2 4 10? 10? 10 10 4 6 6 4 8 6 0 2? *⟩	34
mirex	⟨* 2! * 2 * 8! 10 8 6 6 8 6 0 8 *⟩	34
benzo(a)pyrene	⟨* * 10! * * * 2 4!? 10 * 8 2 10 10 *⟩	32
cadmium	⟨2 2 2 2 6! 6 10 8 8 6 8 6! 8! 6! *⟩	32
diazinon	⟨* 6 * 4 2 2 6 10 6 4 10! 0 0 0 *⟩	32
benzene	⟨6 4 * * * * 0 4 4? 2 4 0 10 10 2⟩	30
chlorpyrifos	⟨2!? 2! * 2!? * * 6 10 10 * 10 * * 0 *⟩	28
methane, dichloro-	⟨4? 2 * * * * 4 4 * 0 6 0 10 10 2⟩	28
benzene, tetrachloro-	⟨* 2 * 4 * 8 * 8 2 2 6 0 8 * 2⟩	26
hexane, hexachlorocyclo	⟨* 2 * 4 2! 4 10?!6 4 2 4 * 6 4 2⟩	26
ethylene oxide	⟨* * * * * * * 4 * * 2 2 10 10 1⟩	*
acrylonitrile	⟨* * * * * * 0 10 * 6 6 4 4 10 1⟩	*
Priority List P3L2 (Modified P3E7 criteria)		
ethane, dichloro-	⟨2? 2 * * * 0? 0 2 * 0 2 0 10 10 1⟩	24
phenol, pentachloro-	⟨* 4 * 4? * 6 6 6 6 4 6 6 6 4 2⟩	24
diethylhexylphthalate	⟨2 4 * 4 * 8 2 2 6 0 4 2 6? 6 *⟩	22
phenol	⟨* 6! * 8!? * * 0 4 2 2 4? 0 2 4! 2⟩	22
ethylene, trichloro-	⟨6! 4! 4! 4! * * 0 4! 2? * 4 2 6 2 1⟩	20
toluene	⟨8 4 * 2 * * 2 6 2 * 2 2 0 0 2⟩	20
carbon tetrachloride	⟨* 2 * * * * 6 4 2? 2? 4 2 0 6 2⟩	18

Table 10 Phase 3 Priority Lists Based on Modified Criteria and Combining Rules

CHEMICAL	PHASE 3 ELEMENT VECTOR	RULE SCORE
Priority List P3L3 (Modified P3E7 criteria)		
benzene, trichloro-	(* 2 * 2 * 2 * 6? * * 4 0 0? * 2)	14
anthracene	(* 2!? * 2 * 4!? 0 4!? 2!? 0 2!? * 0 0 *)	12
benzene, ethyl-	(6 2 * * * * 0 2 * 2 2 0 0 * 3)	12
hexane	(6 2 * * * * 2? 0 * * 4 0 0? * *)	12
List P3L4 (Modified P3E7 criteria) - List sorted based on P3E15 scores.		
benzene, ethyl-	(6 2 * * * * 0 2 * 2 2 0 0 * 3)	
phenol, pentachloro-	(* 4 * 4? * 6 6 6 6 4 6 6 6 4 2)	
phenol	(* 6! * 8!? * * 0 4 2 2 4? 0 2 4! 2)	
toluene	(8 4 * 2 * * 2 6 2 * 2 2 0 0 2)	
carbon tetrachloride	(* 2 * * * * 6 4 2? 2? 4 2 0 6 2)	
benzene, trichloro-	(* 2 * 2 * 2 * 6? * * 4 0 0? * 2)	
ethane, dichloro-	(2? 2 * * * 0? 0 2 * 0 2 0 10 10 1)	
ethylene, trichloro-	(6! 4! 4! 4! * * 0 4! 2? * 4 2 6 2 1)	
List P3L5 (Modified P3E7 criteria)		
dehydroabietic acid	(* 6! * 8 * * * * * * * * * * *)	*
toluene, trichloro-	(* 2 * 4 * 6 * 8 2 * * * * * *)	*

Table 11. Combining-rule Score Distribution for List P3L1 (Modified Criteria and Combining Rule)

Combining-rule Sum	Number of Chemicals
40	0
38	1
36	3
34	5
32	3
30	1
28	2
26	2
*	2

4.5.3.3. Comparison of Modified Vector-System Scores and Independent Ranking

The modifications to the scoring criteria and the combining rules for the Phase 3 vector resulted in minor shifts in the congruence between the vector-system scores and the independent ranking of the test chemicals, without much evidence of improvement. However, there was still good general agreement between the two rating systems. Those chemicals rated as high environmental health hazards were generally found on list P3L1. The test chemicals rated as intermediate were also generally found on list P3L1. Those chemicals rated as low environmental hazards were found on lists P3L2 or P3L3.

Carbon tetrachloride was rated high for potential environmental health hazard, whereas it was on list P3L2 as assessed by the scoring system. This discrepancy appeared to relate to the much heavier weighting of environmental exposure in the vector scoring system than the independent rating. The independent rating place more weight on the potential occupational hazards associated with carbon tetrachloride.

Table 12. Independent Rating of Test Chemicals

	CanTox HAZARD RATING	PHASE 3 COMBINING-RULE SUMS	
acrylonitrile	high	P3L1	*
benzene	high	P3L1	30
benzene, hexachloro-	high	P3L1	36
benzo(a)pyrene	high	P3L1	32
cadmium	high	P3L1	32
carbon tetrachloride	high	P3L2	18
chlorpyrifos	high	P3L1	28
chromium	high	P3L1	34
diazinon	high	P3L1	32
diethylhexylphthalate	high	P3L2	22
ethane, dichloro-	high	P3L2	24
ethylene oxide	high	P3L1	*
hexachlorocyclohexane	high	P3L1	26
lead	high	P3L1	34
methane, dichloro-	high	P3L1	28
mercury	high	P3L1	36
mirex	high	P3L1	34
phenol	high	P3L2	22
phenol, pentachloro-	high	P3L2	24
aluminum	intermediate	P3L1	34
benzene, tetrachloro-	intermediate	P3L1	26
ethylene, trichloro-	intermediate	P3L2	20
fluoride, sodium	intermediate	P3L1	34
hexane	intermediate	P3L3	12
nickel	intermediate	P3L1	38
selenium	intermediate	P3L1	36
anthracene	low	P3L3	12
benzene, ethyl	low	P3L3	12
benzene, trichloro-	low	P3L3	14
toluene	low	P3L2	20
dehydroabietic acid	inadequate information	P3L5	*
toluene, trichloro-	inadequate information	P3L5	*

5. SUMMARY AND GENERAL CONCLUSIONS

Based on the congruency between the prioritization of the 32 test chemicals using the vector scoring system and the independent environmental health hazard ratings, it appeared that the scoring system functioned reasonably well. However, the 32 test chemicals were largely chemicals of known environmental and health concerns, and therefore did not provide a stringent test of the scoring system. Only through continued use with larger numbers of chemicals with less well understood characteristics can the value of the scoring system in the prioritization of chemicals be assessed. Undoubtedly requirements for changes in the elements, their criteria and the combining rules will be identified through experience in the use of the scoring system and through scientific developments in environmental toxicology. The CanTox/Senes team, however, strongly recommends that the basic philosophy of the vector scoring system be maintained. The vector system retains the information critical to the assessment of the potential environmental and health hazards of chemicals and enables a compact, yet comprehensive presentation of that information for user with diverse interests and points of view.

Appendix 1 Summary of the Vector Scoring System Criteria and Combining Rules

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Table A1-1 Phase 2 Scoring Criteria

Table A1-2 Phase 3 Scoring Criteria

Figure A1-1 Phase 2 Combining Rules

Figure A1-2 Phase 3 Combining Rules

TABLE A1-1 SCORING CRITERIA FOR PHASE 2 VECTOR ELEMENTS

ELEMENT NUMBER	UNITS	SCORING CRITERIA 0	1	2	3
P2E1	kg/yr	<5	5 to 300	300 to 10000	>10000
P2E2	% release narrative	0 not used or imported in Ontario	0 to 3 used in closed systems with no routine releases	>3 to 30 Most converted to another product, OR OR largely restricted to industrial uses, OR very slowly released, OR shipped in large batches	>30 Most released directly into the environment, OR used in an open, dispersive manner
P2E3	Measurement basis	No yet detected in Ontario	Infrequently detected at specific locations	Frequently detected but only at specific	Frequently detected over much of Ontario
	Release basis	No known release sites in Ontario	Few release sites concentrated in a few locations	Relatively few release sites, but not concentrated in a few locations	Many release site throughout Ontario
P2E4	narrative	<5% of releases partitions into other media, OR vapour pressure ≤1 kPa, solubility ≤100 g/m^3	≥ one media other than receiving medium containing 5-10% of the amount released, OR vapour pressure ≤1 kPa, solubility ≤100 g/m^3	≥ one media other than receiving medium containing 10-20% of the amount released, OR vapour pressure > 1kPa, solubility >100 g/m^3	> two media other than receiving medium containing more than 20% of the amount released, OR vapour pressure >1 kPa, solubility >100 g/m^3, OR most is associated with fine particles when released into the environment
P2E5	t 1/2 (days) narrative	<10 designated not persistent	10 to <50 slightly persistent	50 to <100 moderately persistent	>100 very persistent
P2E6	BCF Log K_{OW}	≤20 ≤2.0	>20 to 500 >2.0 to 4.0	500 to 15000 >4.0 to 6.0	>15000 >6.0
P2E7	Oral LD_{50} mg/kg	>5000	>500 to 5000	50 to 500	<50
	Dermal LD_{50} mg/kg	>5000	>500 to 5000	50 to 500	<50
	Ihl LC_{50} mg/M^3	>15000	>1500 to 15000	150 to 1500	<150
	Aquatic LC_{50} mg/L	>1000	>100 to 1000	10 to 100	<10

TABLE A1-1 SCORING CRITERIA FOR PHASE 2 VECTOR ELEMENTS

ELEMENT NUMBER	UNITS	SCORING CRITERIA 0	1	2	3
P2E8	Narrative	No evidence of chronic effects in more than one species	Evidence of chronic effects not detrimental to the continued development and well-being of the test system	Evidence of chronic adverse effects in one species but negative data in another species	Evidence of chronic effects in more than one species
P2E9	water mg/L	No effects	>10	0.01 to 10	<0.01
	air ppm	No effects	>10	0.01 to 10	<0.01

TABLE A1-2 SCORING CRITERIA FOR PHASE 3 VECTOR ELEMENTS

ELEMENT NUMBER[a]	Units	0	2	4	6	8	10
P3E1	ug/M^3	<0.03	>0.03-0.3	>0.3-3	>3-30	>30-300	>300
P3E2	ug/L	<0.3	>0.3-3	>3-30	>30-300	>300-3000	>300
P3E3	ug/kg with						
	K_{ow} <1	<0.6	≥0.6-6	>6-60	>60-600	>600-6000	>6000
	K_{ow} 1-3	<6	≥6-60	>60-600	>600-6000	>6000-60000	>60000
	K_{ow} 3-5	<60	≥60-600	>600-6000	>6000-60000	>60000-600000	>600000
	K_{ow} >5	>600	≥600-6000	>6000-60000	>60000-600000	>600000-6000000	>6000000
P3E4	ug/kg	>5	≥5-50	>50-500	>500-5000	>5000-50000	>50000
P3E5	ug/kg	<0.6	≥0.6-6	>6-60	>60-600	>600-6000	>6000
P3E6	ug/kg	<0.6	≥0.6-6	>6-60	>60-600	>600-6000	>6000
P3E7	release-	<1	≥1-10	>10-50	>50-150	>150-300	>300
P3E8	oral LD_{50} mg/kg	>5000	>500-5000	>50-500	>5-50	>0.5-5	≤0.5
	dermal LD_{50} mg/kg	>5000	>500-5000	>50-500	>5-50	>0.5-5	≤0.5
	inhalation LC_{50} mg/m^3	>15000	>1500-15000	>150-1500	>15-150	>1.5-15	≤1.5
	aquatic LC_{50} mg/L	>1000	>100-1000	>10-100	>1-10	>0.1-1	≤0.1
P3E9	aquatic non-mammals -						
	EC_{50}, mg/L	≥20	>20-2	>2-0.2	>0.2-0.02	≤0.02	≤0.02
	MATC, mg/L	≥2	>2-0.2	>0.2-2	>0.02-0.002	≤0.002	≤0.002
	NOAEC, mg/L	≥0.2	>0.2-0.02	>0.02-0.002	>0.002-0.0002	≤0.0002 in one genus	≤0.0002 in different genera
	terrestrial non-mammals - sub-chronic						
	NOEL, mg/kg	≥1000	>100-1000	>10-100	>1-10	≥1	≥1
	chronic NOEL, mg/kg	≥500	>50-500	>5-50	>0.5-5	≥0.5	≥0.5

TABLE A1-2 SCORING CRITERIA FOR PHASE 3 VECTOR ELEMENTS

ELEMENT NUMBER[a]	Units	0	2	4	6	8	10
P3E10	sub-lethal effects on plants - aquatic species						
	EC_{50}, mg/L	≥100	>10-100	>1-10	>0.1-1	0.01-0.1	<0.01
	NOAEC, mg/L	≥10	>1-10	>0.1-1	>0.01-0.1	0.001-0.01	<0.001
	terrestrial species						
	EC_{50}						
	mg/L_3 water	≥100	>10-100	>1-10	>0.1-1	0.01-0.1	<0.01
	mg/m^3 air	≥100000	>10000-100000	>1000-10000	>100-1000	10-100	<10
	mg/kg soil	≥1000	>100-1000	>10-100	>1-10	0.1-1	<0.1
	NOAEC						
	mg/L_3 water	≥10	>1-10	>0.1-1	>0.01-0.1	0.001-0.01	<0.001
	mg/m^3 air	≥10000	>1000-10000	>100-1000	>10-100	1-10	<1
	mg/kg soil	≥100	>10-100	>1-10	>0.1-1	0.01-0.1	<0.01
	OR						
	narrative	no measurable effects	Reversible effects such enzyme induction and sub-cellular effects	Reversible effects, not dysfunctional	Degenerative reversible effects, slightly dysfunctional	Reversible dysfunctional pathological effects	Irreversible dysfunctional pathological effects
P3E11	sub-lethal effects on mammals - oral NOEL						
	mg/kg	>1000	>100-1000	>10-100	>1-10	>0.1-1	<0.1
	ihl NOEL						
	mg/m^3	>3000	>300-3000	>30-300	>3-30	>0.3-3	<0.3
P3E12	narrative	No terata	Terata or	Terata or	Terata or	Terata at	Terata at
	mg/kg	at >1000	developmental anomalies at >50-1000	developmental anomalies at >10-50	developmental anomalies at >1-10	>0.1-10	≤0.1
P3E13	narrative	No evidence of genotox. or mutagen. with adequate testing	Positive results in *in vitro* only	Genotox./ mutagen. in prokaryotic systems only	Effects on DNA, but no direct DNA interactions	Clastogenic effects but no direct interactions with DNA	Genotoxic/ mutagenic usually with direct interactions with DNA

TABLE A1-2 SCORING CRITERIA FOR PHASE 3 VECTOR ELEMENTS

ELEMENT NUMBER[a]	Units	0	2	4	6	8	10
P3E14	narrative	No tumours in adequate studies, and does not interact with genetic material	Tumours in one species, and negative in others, and does not interact with genetic material	Tumours in more than one species, and does not interact with genetic material	Tumours in bioassays at doses causing metabolic saturation, or associated with lesions that pre-dispose to tumours. No interaction with DNA	Indirect acting carcinogen, no interaction with genetic material	Direct acting carcinogen that interacts with genetic material

a

P3E1	Concentrations in air
P3E2	Concentrations in water
P3E3	Concentrations in soils
P3E4	Concentrations in sediments
P3E5	Concentrations in plants
P3E6	Concentrations in animals
P3E7	Frequency of dispersion
P3E8	Acute lethality
P3E9	Sub-lethal effects on non-mammalian species
P3E10	Sub-lethal effects on plants
P3E11	Sub-lethal effects on mammals
P3E12	Teratogenicity
P3E13	Genotoxicity/Mutagenicity
P3E14	Carcinogenicity
P3E15	Undesirable aesthetic properties

FIGURE A1-1 Phase 2 Combining Rules

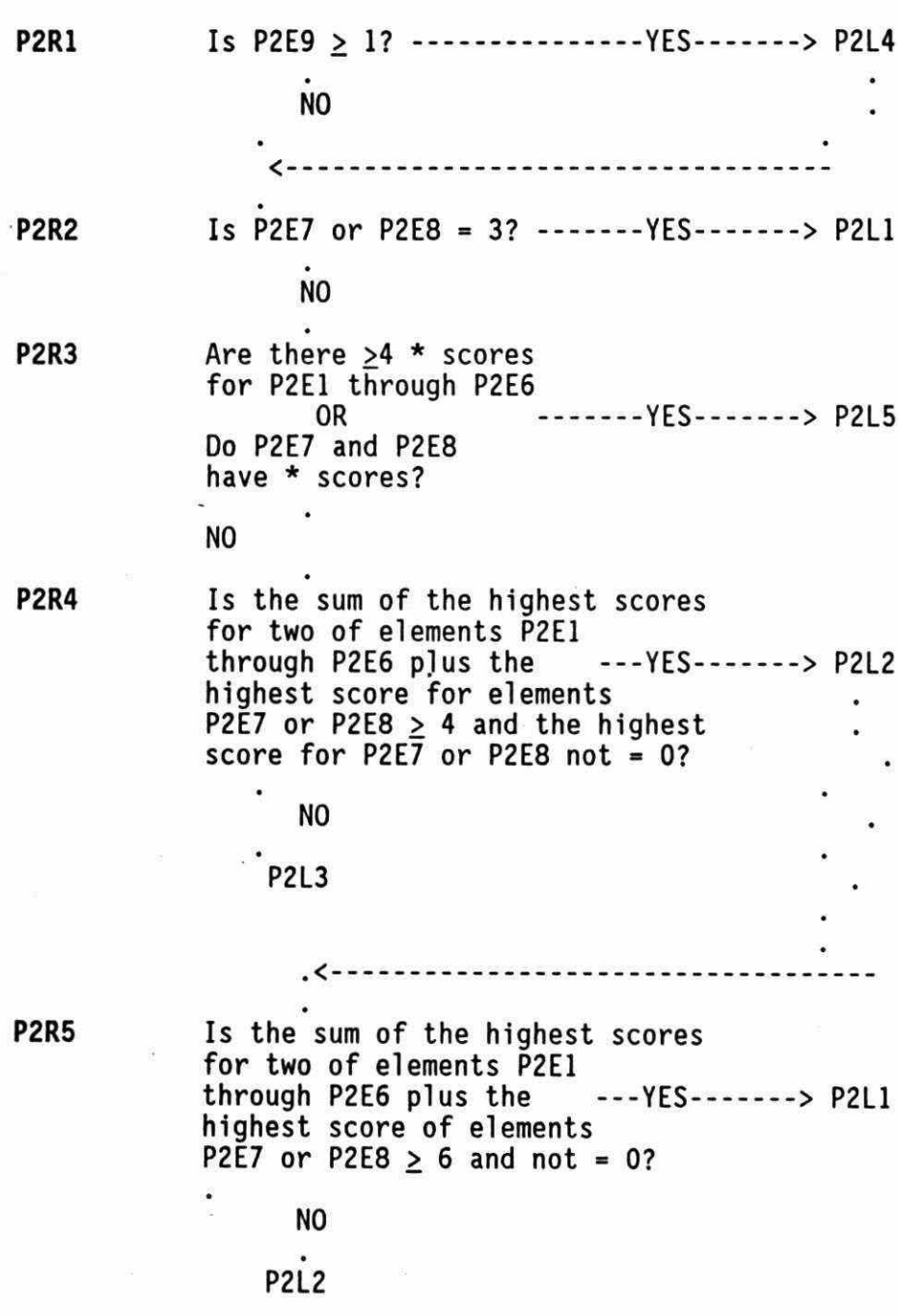

FIGURE A1-2 Phase 3 Combining Rules

P3R1 Are any scores of elements P3E8 P3E8 through P3E14 $\geq$ 8 and any of elements P3E1 through P3E6 >0?

YES ----------> P3L1

NO

P3R2 Are there $\geq$ 6 * scores for elements P3E1 through P3E7 or P3E8 through P3E14?

YES ----------> P3L5

NO

P3R3 Are the two highest scores for elements P3E1 through P3E7 plus the two highest scores for elements P3E8 through P3E14 $\geq$24?

YES ----------> P3L1

NO

P3R4 Are the two highest scores for elements P3E1 through P3E7 plus the two highest scores for elements P3E8 through P3E14 $\geq$14?

YES ----------> P3L2

NO ----------> P3L3

P3R5 Is the chemical on Phase 2 List P2L4?

NO ----------> No action

YES

Has the chemical been selected for regulatory assessment?

YES ----------> No action

NO ----------> P3L4

Appendix 2 CESARS Dossier Format

002 (CAS) CAS Registry Number:

003 (UPD) Latest Update:

004 (MAT) Common Name:

005 (SYN) Synonyms:

006 (RNO) RTECS Number:

007 (FML) Molecular Formula:

008 (CHC) Chemical Class:

009 (HAZ) Hazards:

010 (WRS) Water: Agency Restrictions, Stds., or Criteria:

011 (ARS) Air: Agency Restrictions, Stds., or Criteria:

012 (FRS) Food: Agency Restrictions, Stds., or Criteria:

013 (TRS) Transportation: Agency Restrictions, Stds., or Criteria:

014 (PRS) Pretreatment: Agency Restrictions, Stds., or Criteria:

015 (ORS) Occupa. Exp.: Agency Restrictions, Stds., or Criteria:

016 (LBR) Labeling: Agency Requirements:

017 (DRS) Disposal: Agency Restrictions, Stds., or Criteria:

018 (OAR) Other Agency Restrictions, Stds., or Criteria:

020 (MW) Molecular Weight:

021 (ST) State:

022 (CLR) Color:

023 (ODR) Odor:

024 (MLT) Melting Point (C.):

025 (BLP) Boiling Point (C.):

026 (FLP) Flash Point (C.):

027 (AIP) Autoignition Point (C.):

028 (EXL) Explosion Limits (%):

030 (DEN) Density:

031 (SPG) Specific Gravity:

032 (SOL) Solubility in Water (ppm), @ 25 C.:

033 (SLC) Solubility Text:

034 (VPN) Vapor Pressure (mm Hg), @ 25 C.:

035 (VPT) Vapor Pressure Text:

036 (HLC) Henry's Law Constant (toor/M):

037 (KA) Acidic Dissociation Constant, Ka:

038 (TOD) Theoretical Oxygen Demand:

039 (BOD) Biochemical Oxygen Demand:

040 (COD) Chemical Oxygen Demand:

041 (CNV) Conversion Factor:

042 (KOW) KOW:

043 (LOGP) Log P (n-octanol/water):

044 (OTA) Odor Threshold-Air:

045 (OW) Odor Threshold-Water:

046 (TST) Taste Threshold:

047 (PCP) Other Physical/Chemical Properties:

050 (USS) Common Uses:

051 (PRD) Production:

055 (CSM) Chemical Synthesis Methods:

060 (ORL) Acute Toxicity: Terrestrial Life - Oral LD50:

061 (DML) Acute Toxicity: Terrestrial Life - Dermal LD50:

062 (IHL) Acute Toxicity: Terrestrial Life - Inhalation LC50:

063 (ATTO) Acute Toxicity: Terrestrial Life - Other Studies:

065 (ATH) Acute Toxicity: Human Studies:

066 (FFLC) Acute Toxicity: Aquatic Life - Fish LC50:

067 (FMLC) Acute Toxicity: Aquatic Life - Macroinvertebrates EC50:

068 (ATFO) Acute Toxicity: Aquatic Life - Other Studies:

070 (SFLC) Acute Toxicity: Aquatic Life - Saltwater Fish LC50:

071 (SMLC) Acute Toxicity: Aquatic Life - Saltwater Macroinvertebrates EC50:

072 (ATSO) Acute Toxicity: Aquatic Life - Other Saltwater Studies:

075 (TXTM) Toxic Effects: Terrestrial Life - Macroinvertebrates:

080 (CTL) Subacute - Chronic Effects: Terrestrial Life:

081 (CTN) Subacute - Chronic Effects: Terrestrial Life - NOAELs:

082 (CHS) Subacute - Chronic Effects: Human Studies:

083 (CHN) Subacute - Chronic Effects: Humans - NOAELs:

084 (CFF) Subacute - Chronic Effects: Aquatic Life - Freshwater Fish:

085 (CFM) Subacute - Chronic Effects: Aquatic Life - Freshwater Macroinvertebrates:

086 (CFO) Subacute - Chronic Effects: Aquatic Life - Other Freshwater Studies:

087 (CSF) Subacute - Chronic Effects: Aquatic Life - Saltwater Fish:

088 (CSM) Subacute - Chronic Effects: Aquatic Life - Saltwater Macroinvertebrates:

089 (CSO) Subacute - Chronic Effects: Aquatic Life - Other Saltwater Studies:

090 (NCI) Carcinogenicity: NCI Determination:

091 (IARC) Carcinogenicity: IARC Determination:

092 (OSH) Carcinogenicity: NIOSH Determination:

093 (CARP) Carcinogenicity: Positive References:

094 (CARN) Carcinogenicity: Negative References:

095 (CARA) Carcinogenicity: Animal Studies:

096 (CARH) Carcinogenicity: Humans:

097 (CARO) Carcinogenicity: Other Studies:

100 (MGMP) Mutagenicity: Gene Mutation - Positive References:

101 (MGMN) Mutagenicity: Gene Mutation - Negative References:

102 (MGMS) Mutagenicity: Gene Mutation Studies:

103 (MCEP) Mutagenicity: Chromosomal Effects - Positive References:

104 (MCEN) Mutagenicity: Chromosomal Effects - Negative References:

105 (MCES) Mutagenicity: Chromosomal Effects Studies:

106 (MDDP) Mutagenicity: DNA Damage/Repair - Positive References:

107 (MDDN) Mutagenicity: DNA Damage/Repair - Negative References:

108 (MDDS) Mutagenicity: DNA Damage/Repair Studies:

109 (MOS) Mutagenicity: Other Studies

115 (RMP) Reproductive Effects: Mammals - Positive References:

116 (RMN) Reproductive Effects: Mammals - Negative References:

117 (RMS) Reproductive Effects: Mammalian Studies:

118 (RHS) Reproductive Effects: Human Studies:

119 (ROS) Reproductive Effects: Other Animal Studies:

120 (PTP) Placental Transfer: Positive References:

121 (PTN) Placental Transfer: Negative References:

122 (TERN) Teratogenicity: NOAELs:

123 (PLTT) Phytotoxicity: Terrestrial Plants:

124 (PLTA) Phytotoxicity: Aquatic Plants:

135 (OAE) Other Adverse Effects:

140 (PHM) Pharmacokinetics/Metabolism:

142 (MOA) Mechanisms of Action:

145 (EFS) Environmental Fate: Transport Processes - Sorption:

150 (EFV) Environmental Fate: Transport Processes - Volatilization:

155 (EFBC) Environmental Fate: Transport Processes - Bioac./Bioco.:

160 (EFBD) Environmental Fate: Transform. Processes - Biodegrad.:

165 (EFRO) Environmental Fate: Transform. Processes - Reduc./Oxid.:

170 (EFH) Environmental Fate: Transform. Processes - Hydrolysis:

175 (EFP) Environmental Fate: Transform. Processes - Photolysis:

176 (EFPO) Environmental Fate: Transform. Processes - Photooxid.:

180 (EFMS) Environmental Fate: Microcosm Studies:

181 (EFFS) Environmental Fate: Field Studies:

185 (EFO) Environmental Fate: Other Processes:

190 (AMD) Analytical Methods: Environmental:

195 (TMT) Treatability:

200 (REF) References:

201 (CAVS) Chemical Abstracts Volumes Searched:

201 (P2E1) Score for Sources:

Score:
Data:
Source:

Comments:

202 (P2E2) Score for Releases:

Score:
Data:
Source:

Comments:

203 (P2E3) Score for Environmental Presence:

Score:
Data:
Source:

Comments:

204 (P2E4) Score for Environmental Transport:

Score:
Data:
Source:

Comments:

205 (P2E5) Score for Environmental Persistence:

Score:
Data:
Source:

Comments:

206 (P2E6) Score for Bioaccumulation:

Score:
Data:
Source:

Comments:

207 (P2E7) Score for Acute Toxicity:

Score:
Data:
Source:

Comments:

208 (P2E8) Score for Other Toxicity:

Score:
Data:
Source:

Comments:

209 (P2E9) Score for Aesthetic Properties:

Score:
Data:
Source:

Comments:

301 (P3E1) Score for Concentration in Air:

Score:
Data:
Source:

Comments:

302 (P3E2) Score for Concentration in Water:

Score:
Data:
Source:

Comments:

303 (P3E3) Score for Concentration in Soil:

Score:
Data:
Source:

Comments:

304 (P3E4) Score for Concentration in Sediment:

Score:
Data:
Source:

Comments:

305 (P3E5) Score for Concentration in Plants:

Score:
Data:
Source:

Comments:

306 (P3E6) Score for Concentration in Animals:

Score:
Data:
Source:

Comments:

307 (P3E7) Score for Frequency:

Score:
Data:
Source:

Comments:

308 (P3E8) Score for Acute Lethality:

Score:
Data:
Source:

Comments:

309 (P3E9) Score for Sub-Lethal Effects on Non-Mammals:

Score:
Data:
Source:

Comments:

310 (P3E10) Score for Sub-Lethal Effects on Plants:

Score:
Data:
Source:

Comments:

311 (P3E11) Score for Sub-Lethal Effects on Mammals:

Score:
Data:
Source:

Comments:

312 (P3E12) Score for Teratogenic Effects:

Score:
Data:
Source:

Comments:

313 (P3E13) Score for Mutagenic Effects:

Score:
Data:
Source:

Comments:

314 (P3E14) Score for Carcinogenic Effects:

Score:
Data:
Source:

Comments:

315 (P3E15) Score for Aesthetic Properties:

Score:
Data:
Source:

Comments:

Appendix 3 Environmental Health Hazard Evaluation Format

1.0	**CHEMICAL CHARACTERISTICS**
1.1	Structure and Chemical/Physical Constants
1.2	Environmental Fate
1.3	Major Exposure Routes
1.4	Pharmacokinetics and Biotransformation
2.0	**ECOLOGICAL EFFECTS**
2.1	Aquatic Animals
2.2	Terrestrial Animals
2.4	Aquatic and Terrestrial Plants
3.0	**TOXICOLOGICAL EFFECTS**
3.1	Functional Effects
3.2	Morphological Effects
3.3	Observed Effect and No-effect Levels
4.0	**GENOTOXIC EFFECTS**
4.1	Mutagenicity/genotoxicity
4.2	Tests for Cell Transformation, Tumour Promotion and Cocarcinogenicity
5.0	**NEOPLASTIC EFFECTS**
5.1	Test Data Available
5.2	Histogenic Tumor Sites
5.3	Histologic and Biologic Characteristics of Tumors Observed
5.4	Latency Period and Dose-response Relationships
5.5	Background Tumor Incidence Rates
6.0	**HUMAN STUDIES**
6.1	Case Studies
6.2	Epidemiologic and Health Surveillance Data

7.0 **SUMMARY AND ASSESSMENT OF POTENTIAL HAZARDS**

7.1 Summary of Critical Data

7.2 Assessment of Hazard Potential

8.0 **REFERENCES**

Appendix 4 Vector System Scores for Test Chemicals

Contents of Appendix

Table A4-1 Phase 2 Element Scores for Test Chemicals (Scored with Unmodified Criteria)

Table A4-2 Phase 3 Element Scores for Test Chemicals (Scored with Unmodified Criteria)

Table A4-1 Phase 2 Element Scores for Test Chemicals
(Scored with Unmodified Criteria)

CHEMICAL	PHASE 2 ELEMENT SCORES								
	E1	E2	E3	E4	E5	E6	E7	E8	E9
acrylonitrile	3	2	*	3	0	1	3	3	1
aluminum	3	3	3	0	3	2	3!?	2!	*
anthracene	3	3	3	0	0	2	1!	1	*
benzene	3	3	3	3	0	1	2	3	2
benzene, ethyl-	3	1	1	2	0	1	1	1	3
benzene, hexachloro-	3?	3?	3	1	3	3	3	3	*
benzene, tetrachloro-	*	2	1	1	*	2	3	3	2
benzene, trichloro-	*	2	2	2	*	2	3!?	3?	2
benzo(a)pyrene	*	3	3	3	1	3	2!	3	*
cadmium	3!	3	3	1	3	1!	3!	3	*
carbon tetrachloride	3	3	3	3	2	1	2	3	2
chlorpyrifos	2	3!?	3	1	2	2	3	2	*
chromium	3	3	3	3	3	2	2	3	2
dehydroabietic acid	*	2?	2?	*	*	1?	*	*	*
diazinon	2	3	3	2	2	1	3	1	*
diethylhexylphthalate	3?	3	3	3	1	2	2	3	*
ethane, dichloro-	3	2	2	3	0	1	1	3	1
ethylene oxide	3?	2	2	2	*	*	2	3	1
ethylene, trichloro-	3!?	2	3	3	0	2!	2!	3!	1
fluoride	3!	3	3	3	3!?	1	3	3	2
hexachlorocyclohexane	*	3	3	0	3!?	2!	3	3	2
hexane	3	3	3	3	1	2?	0	3	*
lead	3	3	3	1	3	2	3	3	*
methane, dichloro-	3	3	3	3	1	0	2	3	2
mercury	3	2	3	1	3	3!	3	3	0?
mirex	3!?	3!	2	1	3	3	3?	3	*
nickel	3	3	3	2	3	2	3!	3	*
phenol	3	3	3	3	0	0	2	2	2
phenol, pentachloro-	3!	3	3	1	3	2	3	3	2
selenium	3	2	3	1	3	2	3	3	2
toluene	3	3	3	2	0	1	3	3	2
toluene, trichloro-	*	1	2	*	*	2	3	3	*

Table A4-2 Phase 3 Element Scores for Test Chemicals
(Scored with Unmodified Criteria)

CHEMICAL	PHASE 3 ELEMENT SCORES														
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
acrylonitrile	*	*	*	*	*	*	4	10	*	6	6	4	4	10	1
aluminum	2	8	*	10	10?	*	10	8?	6?	6?	6?	2	0?	*	*
anthracene	*	2!?	*	2	*	4!?	10	4!	2!?	0	2!?	*	0	0	*
benzene	6	4	*	*	*	*	10	4	4?	2	4	0	10	10	2
benzene, ethyl-	6	2	*	*	*	*	2	2	*	2	2	0	0	*	3
benzene, hexachloro-	*	6	*	4	*	2	10	6	10	*	10	0?	0?	10?	*
benzene, tetrachloro-	*	2	*	4	*	8	8	8	2	2	6	0	8	*	2
benzene, trichloro-	*	2	*	2	*	2	2?	6?	*	*	4	0	0?	*	2
benzo(a)pyrene	*	*	10!	*	*	*	10	4!?	10	*	8	2	10	10	*
cadmium	2	2	2	2	6!	6	10	8	8	6	8	6!	8!	6!	*
carbon tetrachloride	*	2	*	*	*	*	10	4	2?	2?	4	2	0	6	2
chlorpyrifos	2!?	2!	*	2!?	*	*	8	10	10	*	10	*	*	0	*
chromium	2	4	4	8	8	6	10	6	6	2	6	6	10?	8	2
dehydroabietic acid	*	6!	*	8	*	*	*	*	*	*	*	*	*	*	*
diazinon	*	6	*	4	2	2	8	10	6	4	10!	0	0	0	*
diethylhexylphthalate	2	4	*	4	*	8	10	2	6	0	4	2	6?	6	*
ethane, dichloro-	2?	2	*	*	*	0?	4	2	*	0	2	0	10	10	1
ethylene oxide	*	*	*	*	*	*	4	4	*	*	2	2	10	10	1
ethylene, trichloro-	6!	4!	4!	4!	*	*	8	4!	2?	*	4	2	6	2	1
fluoride, sodium	4	8	6	*	8	8	10	6	*	*	8	4	8	0?	2
hexane, hexachlorocyclo	*	2	*	4	2!	4	6!	6	4	2	4	*	6	4	2
hexane	6	2	*	*	*	*	10	0	*	*	4	0	0?	*	*
lead	2	4	10?	10?	10	10	10	6	6	4	8	6	0	2?	*
methane, dichloro-	4?	2	*	*	*	*	10	4	*	0	6	0	10	10	2
mercury	2	2	6	6	6!	8!	10	8	4?	10	10	6	6	0?	0?
mirex	*	2!	*	2	*	8!	10	8	6	6	8	6	0	8	*
nickel	4!	4!	2	10	10!	*	10	4	4	4	10	6	6!	8	*
phenol	*	6!	*	8!?	*	*	10	4	2	2	4?	0	2	4!	2
phenol, pentachloro-	*	4	*	4?	*	6	10	6	6	4	6	6	6	4	2
selenium	*	4!	6	10	10	*	10	6	8!	6	8	6	6	6	2
toluene	8	4	*	2	*	*	10	6	2	*	2	2	0	0	2
toluene, trichloro-	*	2	*	4	*	6	2	8	2	*	*	*	*	*	*

Appendix 5 Modified Vector System Scores for Test Chemicals

Appendix Table of Contents

Table A5-1	Phase 2 Element Scores for Test Chemicals (Scored with Modified Criteria)
Table A5-2	Phase 3 Element Scores for Test Chemicals (Scored with Modified Criteria)
Figure A5-1	Modified Phase 2 Combining Rules
Figure A5-2	Modified Phase 3 Combining Rules

Table A5-1 Phase 2 Element Scores for Test Chemicals
(Scored with Unmodified Criteria)

CHEMICAL	PHASE 2 ELEMENT SCORES								
	E1	E2	E3	E4	E5	E6	E7	E8	E9
acrylonitrile	3	2	*	3	0	1	3	3	1
aluminum	3	3	3	0	3	2	3!?	2!	*
anthracene	3	3	3	0	0	2	1!	1	*
benzene	3	3	3	3	0	1	2	3	2
benzene, ethyl-	3	1	1	2	0	1	1	1	3
benzene, hexachloro-	3?	3?	3	1	3	3	3	3	*
benzene, tetrachloro-	*	2	1	1	*	2	3	3	2
benzene, trichloro-	*	2	2	2	*	2	3!?	3?	2
benzo(a)pyrene	*	3	3	3	1	3	2!	3	*
cadmium	3!	3	3	1	3	1!	3!	3	*
carbon tetrachloride	3	3	3	3	2	1	2	3	2
chlorpyrifos	2	3!?	3	1	2	2	3	2	*
chromium	3	3	3	3	3	2	2	3	2
dehydroabietic acid	*	2?	2?	*	*	1?	*	*	*
diazinon	2	3	3	2	2	1	3	1	*
diethylhexylphthalate	3?	3	3	3	1	2	2	3	*
ethane, dichloro-	3	2	2	3	0	1	1	3	1
ethylene oxide	3?	2	2	2	*	*	2	3	1
ethylene, trichloro-	3!?	2	3	3	0	2!	2!	3!	1
fluoride	3!	3	3	3	3!?	1	3	3	2
hexachlorocyclohexane	*	3	3	0	3!?	2!	3	3	2
hexane	3	3	3	3	1	2?	0	3	*
lead	3	3	3	1	3	2	3	3	*
methane, dichloro-	3	3	3	3	1	0	2	3	2
mercury	3	2	3	1	3	3!	3	3	0?
mirex	3!?	3!	2	1	3	3	3?	3	*
nickel	3	3	3	2	3	2	3!	3	*
phenol	3	3	3	3	0	0	2	2	2
phenol, pentachloro-	3!	3	3	1	3	2	3	3	2
selenium	3	2	3	1	3	2	3	3	2
toluene	3	3	3	2	0	1	3	3	2
toluene, tetrachloro-	*	1	2	*	*	2	3	3	*

Table A5-2 Phase 3 Element Scores for Test Chemicals
(Scored with Modified Criteria)

CHEMICAL	PHASE 3 ELEMENT SCORES														
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
acrylonitrile	*	*	*	*	*	*	0	10	*	6	6	4	4	10	1
aluminum	2	8	*	10	10?	*	6	8?	6?	6?	6?	2	0?	*	*
anthracene	*	2!?	*	2	*	4!?	0	4!	2!?	0	2!?	*	0	0	*
benzene	6	4	*	*	*	*	0	4	4?	2	4	0	10	10	2
benzene, ethyl-	6	2	*	*	*	*	0	2	*	2	2	0	0	*	3
benzene, hexachloro-	*	6	*	4	*	2	10	6	10	*	10	0?	0?	10?	*
benzene, tetrachloro-	*	2	*	4	*	8	*	8	2	2	6	0	8	*	2
benzene, trichloro-	*	2	*	2	*	2	*	6?	*	*	4	0	0?	*	2
benzo(a)pyrene	*	*	10!	*	*	*	2	4!?	10	*	8	2	10	10	*
cadmium	2	2	2	2	6!	6	10	8	8	6	8	6!	8!	6!	*
carbon tetrachloride	*	2	*	*	*	*	6	4	2?	2?	4	2	0	6	2
chlorpyrifos	2!?	2!	*	2!?	*	*	6	10	10	*	10	*	*	0	*
chromium	2	4	4	8	8	6	6	6	6	2	6	6	10?	8	2
dehydroabietic acid	*	6!	*	8	*	*	*	*	*	*	*	*	*	*	*
diazinon	*	6	*	4	2	2	6	10	6	4	10!	0	0	0	*
diethylhexylphthalate	2	4	*	4	*	8	2	2	6	0	4	2	6?	6	*
ethane, dichloro-	2?	2	*	*	*	0?	0	2	*	0	2	0	10	10	1
ethylene oxide	*	*	*	*	*	*	*	4	*	*	2	2	10	10	1
ethylene, trichloro-	6!	4!	4!	4!	*	*	0	4!	2?	*	4	2	6	2	1
fluoride, sodium	4	8	6	*	8	8	10	6	*	*	8	4	8	0?	2
hexane, hexachlorocyclo	*	2	*	4	2!	4	10?!	6	4	2	4	*	6	4	2
hexane	6	2	*	*	*	*	2?	0	*	*	4	0	0?	*	*
lead	2	4	10?	10?	10	10	4	6	6	4	8	6	0	2?	*
methane, dichloro-	4?	2	*	*	*	*	4	4	*	0	6	0	10	10	2
mercury	2	2	6	6	6!	8!	8	8	4?	10	10	6	6	0?	0?
mirex	*	2!	*	2	*	8!	10	8	6	6	8	6	0	8	*
nickel	4!	4!	2	10	10!	*	10	4	4	4	10	6	6!	8	*
phenol	*	6!	*	8!?	*	*	0	4	2	2	4?	0	2	4!	2
phenol, pentachloro-	*	4	*	4?	*	6	6	6	6	4	6	6	6	4	2
selenium	*	4!	6	10	10	*	4	6	8!	6	8	6	6	6	2
toluene	8	4	*	2	*	*	2	6	2	*	2	2	0	0	2
toluene, trichloro-	*	2	*	4	*	6	*	8	2	*	*	*	*	*	*

FIGURE A5-1 **Phase 2 Combining Rules**

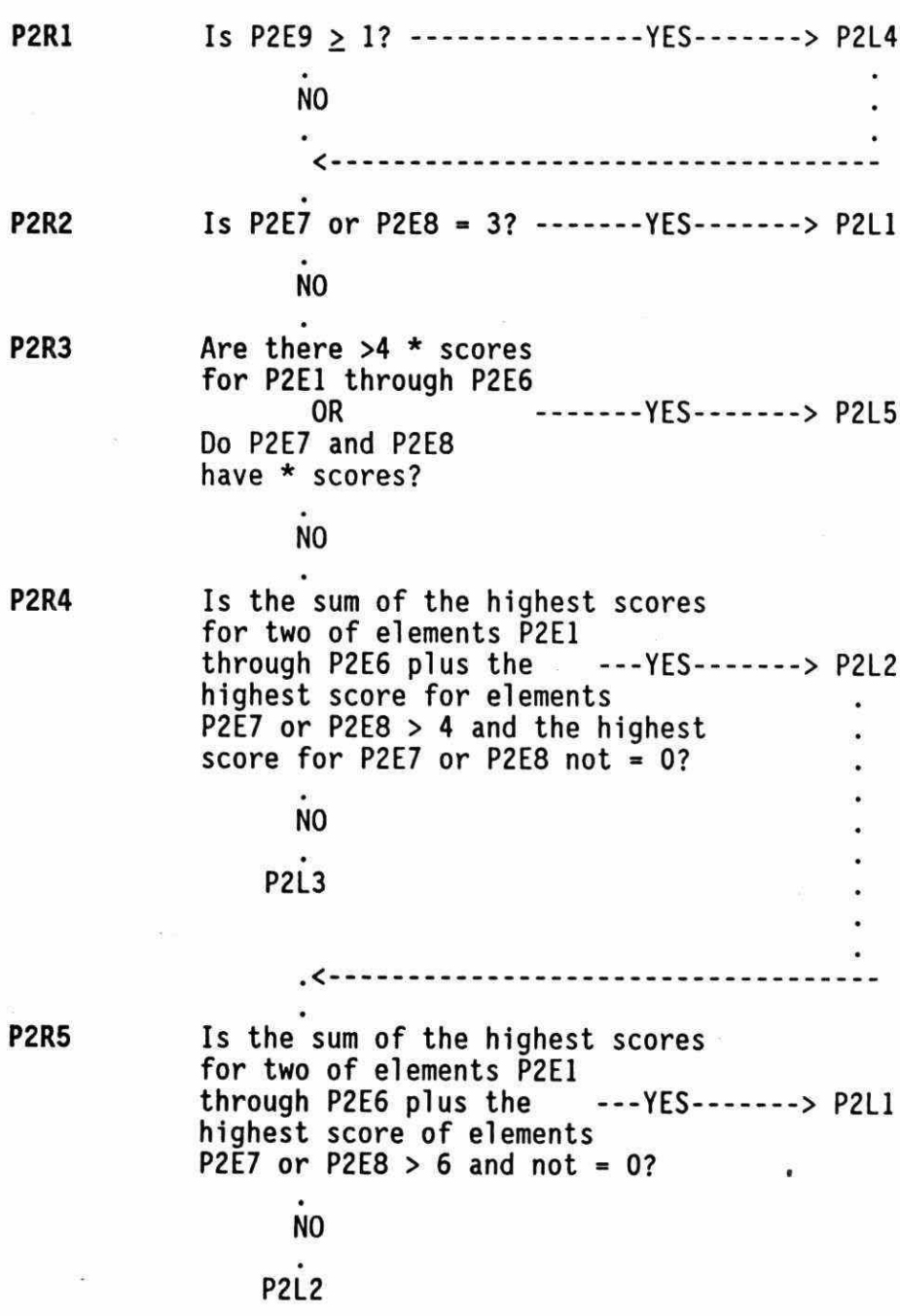
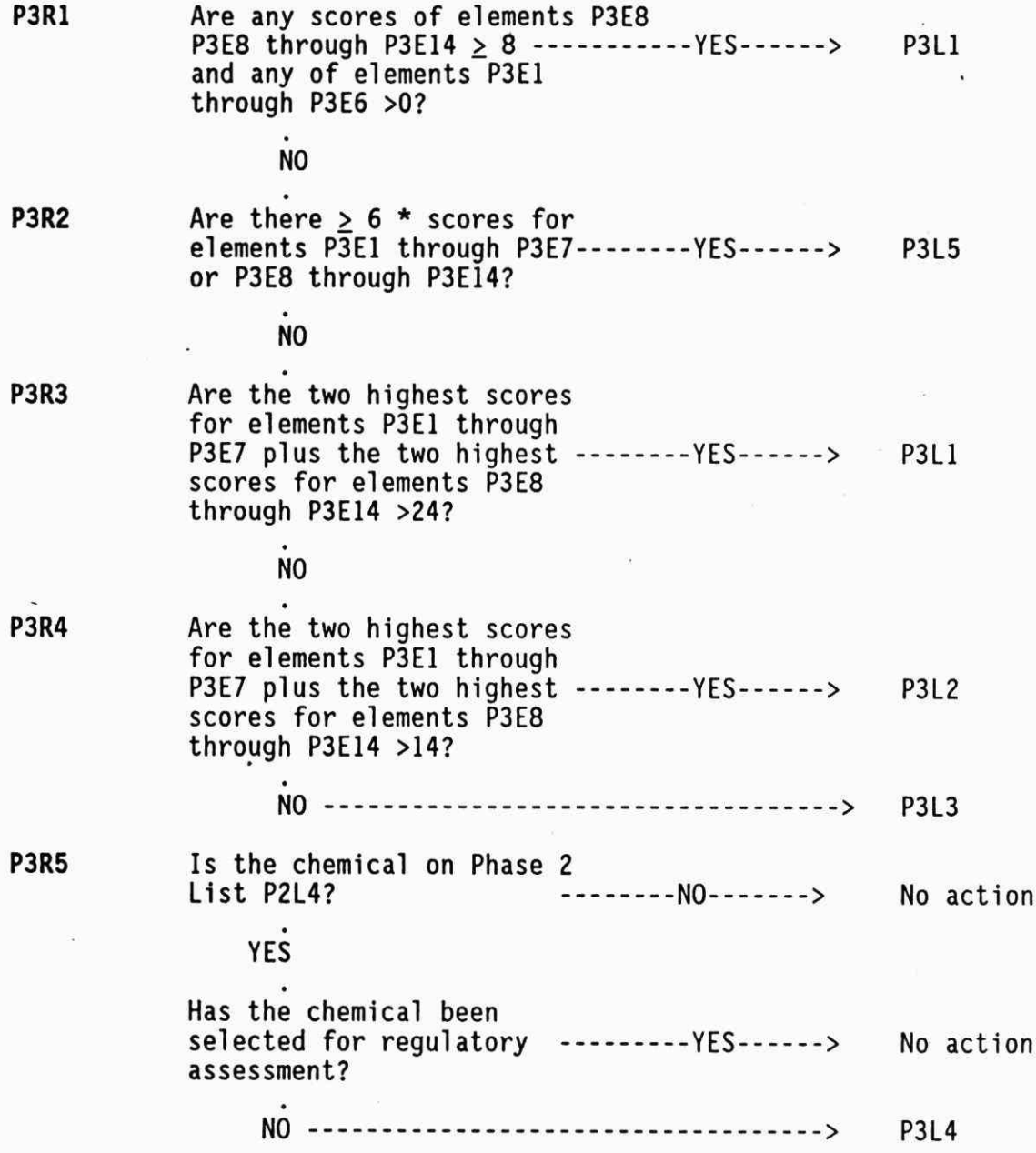
FIGURE A5-2 Phase 3 Combining Rules